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Growth and Salt Uptake of Date Seedlings in Relation to Salinity of the Irrigation Water

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INTRODUCTION

Field experiments to determine the influence of several levels of soil salinity on growth and salt uptake of young date palms, *Phoenix dactylifera* L., were recently reported (2). In these tests, some date roots grew under the trenches between plots and were thus exposed to salinity conditions different from those maintained in the respective plots from which they had grown. Because of this possible source of error and also because only pinna samples were analyzed to determine salt accumulation, we thought it would be desirable to compare the results obtained in the field tests with those from similar tests conducted on potted seedlings in the greenhouse under controlled conditions. We also wished to sample entire plants, rather than only pinnae, for chemical analysis.

This paper, accordingly, reports the results of greenhouse experiments with seedlings of two varieties of date to determine the influence of several levels of salinity on growth in relation to salt accumulation.

MATERIALS AND METHODS

Seed of the varieties 'Deglet Noor' and 'Medjool' were planted in plastic pots in a medium of equal volumes of peat moss and vermiculite. The seedlings were grown in a greenhouse where daily temperatures usually ranged between 60°F and 95°F, with an occasional maximum of 100°F. They were watered for 6 months with Hoagland's nutrient solution (5) or with tap water that contained 22 parts per million (ppm) of sodium (Na) and 11 ppm of chlorine (Cl). Just before salinity treatments were started on April 2, 1965, the plants, which had two mature leaves, were thinned to four or five per pot.

The salinity treatments were the same as those applied to young Deglet Noor and Medjool palms grown in field plots (2), except that the salts required, sodium and calcium chlorides in equivalent amounts, were added to $\frac{1}{3}$ strength Hoagland's nutrient solution made up with tap water.

The control plants were watered with $\frac{1}{3}$ strength Hoagland's nutrient solution. The four salinity treatments consisted of watering with solutions containing total salt concentrations of 6,000, 12,000, 18,000

or 24,000 ppm total salt. The solutions were made up from the estimated weights of salts needed, but since their purity and moisture content varied, the approximate concentrations were estimated from electrical conductivity determinations and the graph in Figure 3 of the United States Department of Agriculture Handbook No. 60 (7) that shows the relationship between concentration of sodium and calcium chloride solutions and electrical conductivity ($EC \times 10^3$ at 25°C). The approximate salt content, the electrical conductivity, and the estimated osmotic pressure of the $\frac{1}{3}$ strength Hoagland's solution applied to control plants and of the salt solutions applied under the four salinity treatments are listed in Table 1.

Treatments were replicated 10 times. One pot of Deglet Noor and one pot of Medjool seedlings were placed in each plot, and the arrangement of plots on the greenhouse bench was in two 5 x 5 Latin squares. The pots were watered every 1 or 2 days as needed, with such liberal amounts of solution as to cause copious drainage and thorough flushing out of the rooting medium. At the start of the salt treatments, the concentration of salt solution applied was increased by 6,000 ppm per day until the plants under each treatment were receiving solutions of the assigned concentration. Leaf growth rate was determined at intervals of 1 or 2 weeks by measuring the length of an immature, labeled leaf in each pot. As labeled leaves reached about $\frac{3}{4}$ the length of mature leaves, younger ones were selected

for measurement. The duration of the salinity treatments from the time plants in all treatments were receiving salt solutions of the designated strength was 54 days. At the end of the test some leaves on many plants were dying back at the tips. Some of this seemed to be related to salt treatment, so the total length of dead leaf tips on plants under each treatment was measured.

At the termination of the experiment on May 27, 1965, the plants were removed from the pots and most of the adhering peat-vermiculite medium washed off by hosing with tap water. Many small rootlets had grown through or adhered to particles of the culture medium, which had to be picked off the roots by hand. Many of the fibrous roots were lost because of the difficulty in separating them from the culture medium. A few roots had grown through the drainage holes in the sides of the pots and some had penetrated the cracks between the boards of the greenhouse bench. This was a source of error not observed until the pots were removed for sampling. The tops and roots were washed with tap water as quickly as possible to avoid excessive leaching and blotted with toweling; then roots and tops were separated and placed in paper bags for drying in a forced draught oven at 65°C. Each sample consisted of the tops or the roots of the four or five plants from one pot. The dry samples were weighed, ground, and analyzed for chlorides by electrometric titration and for sodium by flame photometry.

TABLE 1. Approximate salt content, electrical conductivity ($EC \times 10^3$ at 25°C) and estimated osmotic pressure of irrigation water applied to date seedlings

Treatment: approximate salt content	Electrical conductivity ($EC \times 10^3$ at 25°C)	Estimated osmotic pressure
(ppm)	(mmhos/cm)	(atmospheres)
520 (control)	1.1	0.3
6,000	11.0	3.7
12,000	20.0	7.1
18,000	29.5	9.8
24,000	38.0	14.2

RESULTS

TABLE 2. Average chloride and sodium content of dry tops and roots of 'Deglet Noor' and 'Medjool' seedlings in relation to salinity of the irrigation water¹

Treatment: salt content of water	'Deglet Noor'				'Medjool'			
	Tops		Roots		Tops		Roots	
	Cl	Na	Cl	Na	Cl	Na	Cl	Na
(ppm)	%	%	%	%	%	%	%	%
Control	1.17 a	0.06 a	2.54 a	0.57 a	1.21 a	0.07 a	2.65 a	0.70 a
6,000	1.41 b	0.13 b	4.13 b	1.17 b	1.36 b	0.13 b	4.33 b	1.34 b
12,000	1.45 bc	0.18 c	4.31 b	1.30 bc	1.32 b	0.14 b	4.45 b	1.40 b
18,000	1.53 bc	0.23 d	4.34 b	1.34 c	1.40 bc	0.18 c	4.48 b	1.44 b
24,000	1.59 c	0.27 e	4.31 b	1.40 c	1.49 c	0.23 d	4.64 b	1.50 b

¹ Averages having different letters are significantly different at the 5% level of probability.

TABLE 3. Comparative accumulation of chloride and sodium in roots and tops of 'Deglet Noor' and 'Medjool' seedlings in relation to salinity of the irrigation water

Treatment: salt content of water	'Deglet Noor'		'Medjool'	
	Ratios:		Ratios:	
	Cl in roots Cl in tops	Na in roots Na in tops	Cl in roots Cl in tops	Na in roots Na in tops
(ppm)				
Control	2.17	9.50	2.19	10.00
6,000	2.93	9.00	3.18	10.30
12,000	2.97	7.22	3.37	10.00
18,000	2.84	5.83	3.20	8.00
24,000	2.71	5.19	3.12	6.52

TABLE 4. Average leaf growth rate¹ and average dry weight² of 'Deglet Noor' and 'Medjool' seedlings in relation to salinity of the irrigation water

Treatment:	'Deglet Noor'				'Medjool'			
	Growth		Dry wt.		Growth		Dry wt.	
	Mm per day	% of control	Gms % of control		Mm per day	% of control	Gms % of control	
(ppm)								
Control	7.4 a ³	100	4.35 a	100	6.4 a	100	5.07 a	100
6,000	4.5 b	65	3.15 b	72	4.5 b	72	4.44 b	88
12,000	3.1 c	46	2.81 bc	65	2.6 c	42	3.84 c	76
18,000	2.3 c	27	2.69 bc	62	2.1 d	33	3.45 cd	68
24,000	1.3 d	18	2.42 c	56	1.1 e	18	3.12 d	62

¹ Avg. leaf growth rate = avg. elongation of immature leaves as millimeters per day.

² Avg. dry weight = avg. dry weight per plant of top plus all roots recovered.

³ Averages having different letters are significantly different at the 5% level of probability.

The results of chemical analyses of tops and roots show that the large variations in concentration of salt in the irrigation water had remarkably little effect upon the amount of Cl and Na that accumulated in the plants under the different salinity treatments (Table 2). The general trend of accumulation of Cl and Na ions in the plants was, as would be expected, an increase as the salt concentration of the irrigation water increased, but the accumulation of Cl and Na in the plants was far from proportional to the concentration of those ions in the water with which the plants under the different treatments were irrigated. A fourfold increase in concentration of total salt, mostly calcium and sodium chlorides, in the irrigation water less than doubled the concentration of Cl in the tops or roots of either variety and only about doubled Na in the tops, but not in the roots. With increasing salt content of the irrigation water, there was a somewhat more consistent increase in the Na content than in Cl content in the tops of seedlings of both varieties. In the Deglet Noor seedlings, in fact, there was a significant difference between all treatments in Na content of tops.

The amounts of Cl and Na found in roots as compared to tops show that the roots accumulated two or three times as much Cl and five to 10 times as much Na as the tops (Table 3). With increasing salt content of the substrate and increasing amounts of sodium accumulated in the roots, the differences in amounts of Na accumulated by roots and tops became less. In the Medjool seedlings, for example, roots of plants under the 6,000 ppm treatment had 10.3 times as much Na as the tops, but roots of plants under the 24,000 ppm treatment had only 6.5 times as much Na as the tops. This suggests that at relatively low levels of Na accumulation in the roots there is proportionately less translocation into the tops than at relatively high levels of Na accumulation in the roots. Similar marked differences in Na accumulation in roots and tops have been found in other plants, e.g., beans and corn; but why Na translocation from roots to tops is restricted in some kinds of plants and not in others is not understood (3, 6, 8).

The average rate of leaf elongation of plants under salt treatment, as compared with that of control plants, showed that during the first 5 days after plants in all treatments were receiving salt solutions of the full strength assigned to them the average growth rate of all plants under salt treatment was depressed. The average growth rates of leaves for the entire period of salt treatment show that with increasing salt concentration of the irrigation water the depression of growth became greater; however,

as may be seen by a comparison of the relative growth rates expressed as percentages of the controls (Table 4), each succeeding increment of salt was less effective in depressing growth than the preceding ones.

The average dry weights per plant attained in control cultures and in those under 6,000 and 12,000 ppm salt treatments were significantly different from each other, but at higher levels of salinity the differences between treatments were usually not statistically significant (Table 4). The relative dry weights (% of control) indicate, however, that there was a progressive depression in dry weight with increasing salinity of the substrate.

Some dying back of tips of leaves of control plants as well as those under salt treatment occurred, so that only by comparing the total length of dead leaf tips could we estimate the effect of salt on death of leaf tips. The differences in length of dead tissue at the leaf tips seemed in most cases unrelated to treatment except that the length of dead leaf tips of Deglet Noor seedlings that received 24,000 ppm of salt was significantly greater (at the 1% level of probability) than that in other treatments, and this difference must have resulted in part, at least, from salt injury. There were no significant differences in length of dead leaf tips between the control and the treated Medjool seedlings.

DISCUSSION AND CONCLUSIONS

In plants in all salt treatments the percentages of Cl and Na in the tops of Deglet Noor seedlings were slightly higher than in the tops of Medjool seedlings, but in the roots the reverse was true. This apparent anomaly may have resulted from a characteristic difference in the distribution of Cl and Na in the two varieties or possibly from some difference in proportion of inert tissue to living cells, in which salt would accumulate, in tops and roots of the two varieties.

With the possible exception of Na accumulation in leaves, differences in salt concentration of the substrate had remarkably little effect on the percentages of Cl and Na that accumulated in the tissues of plants under the different salt treatments. The Cl and Na contents of the tissues were nearly the same regardless of salt treatment. What mechanism controls salt accumulation in plants is not known, but in the date palm there seems to be some mechanism that is increasingly effective in repressing Cl and Na uptake and accumulation as the concentration of those ions in the substrate increases. This apparent ability of the date

palm when grown in a highly saline substrate to repress salt uptake with increasing effectiveness as salinity increases was also observed in controlled salinity tests on young date palms in field plots (2).

The unexpectedly high percentages of Cl and Na in the control plants watered with nutrient solution containing only about 11 ppm of Cl and 22 ppm of Na may have resulted in part from salt uptake by a few roots that grew through drain holes of the pots, though high efficiency of absorption from very dilute solution may also be in part responsible for the relatively high salt uptake of the control plants.

Depression of growth by salinity in many plants has been attributed largely to the osmotic effect of the salts in solution in the substrate (1, 4). This seems to have been the principal cause of depression of growth of the date seedlings in this test. Lack of definite symptoms of salt toxicity and prompt depression of leaf growth after application of saline water and before much salt could have been absorbed are evidence of an osmotic rather than a toxic effect of the salts. Furthermore, if growth depression had been caused mainly by toxic effects of the salts, there would probably have been little difference in growth rate of plants under the different salt treatments because there was relatively little difference in Cl and Na accumulation of plants under the different treatments. Depression of growth was more closely related to osmotic pressure of the salt solutions with which plants were watered than to concentration of Na and Cl ions in tissues.

One criterion of salt tolerance is the growth rate of the salt-affected plants in relation to plants grown under conditions of salinity too low to affect growth adversely. On this basis the date seedlings under salt treatments in this test showed very high salt tolerance. Irrigation water containing 6,000 ppm of total salts reduced their growth rate to not quite 50% of that of the control plants. Under conditions favoring high rates of transpiration, however, depression of growth by the salt treatments applied in this test would probably be appreciably greater.

The results obtained in this experiment with potted seedlings of Deglet Noor and Medjool, in general, confirm the results obtained in a previous experiment with offshoots of Deglet Noor and Medjool in field plots (2). In both experiments depression of growth was more closely related to salinity of the irrigation water than to salt content of the plants.

ABSTRACT

Potted seedlings of the date, *Phoenix dactylifera* L., received the following watering treatments: control, nutrient solution and salt solutions containing 6,000, 12,000, 18,000 or 24,000 ppm of total salts. Cl and Na accumulation of tops and roots was not closely related to salt concentration of the water. A fourfold increase in salt content of the water less than doubled the Cl content of tops and about doubled Na in roots. Roots accumulated two or three times as much Cl and five to 10 times as much Na as the tops. With increasing salt content of substrate and of roots, the differences in amounts of Na accumulated by tops and roots became less. As salt concentration of the substrate increased, leaf growth rate decreased; but each succeeding increment of salt was less effective in depressing growth than the preceding ones. At salinity levels above 12,000 ppm differences between treatments in plant-dry-weight were insignificant. In the date there seems to be a mechanism that is increasingly effective in repressing uptake of Cl and Na ions as the concentration of those ions in the substrate increases. Depression of growth was more closely related to osmotic pressure of the salt solutions with which plants were watered than to accumulation of Na and Cl ions in plants.

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TESTS OF CHEMICALS FOR THINNING AND PRODUCING SEEDLESS 'MEDJOOL' DATES

By D. O. KETCHIE¹

The 'Medjool' date palm, *Phoenix dactylifera* L., is customarily hand-thinned by removing some strands from the bunches and removing fruit from the remainder of the strands. Thinning fruit from the strands is necessary to obtain large fruit and to reduce mechanical damage to mature fruit from adjacent fruit. Hand thinning is expensive; therefore, a method to eliminate it and maintain high quality is desirable.

Furr and Hewitt (3) reported two methods that showed some promise: pollen dilution and chemical thinning. They found that pollen dilution, which consists of pollinating with a mixture of viable and dead pollen, has three disadvantages: (a) introduction of pollen from other sources by wind may increase set, (b) to insure adequate set of fruit, there is a tendency to use too much viable pollen, and (c) an unfavorable season may lead to crop failure. In chemical thinning trials, six chemicals at various concentrations were applied to half bunches at different periods after inflorescence emergence from the spathe. The results indicated that four chemicals could be used: sodium dinitro-ortho-cresylate (DNC); naphthaleneacetic acid (NAA); 2,4,5 trichlorophenoxy acetic acid (2,4,5-T); dinitro-ortho-secondary-butylphenol (DNBP). The first purpose of the present work was to investigate further the use of the four materials and to try two additional materials: 2,4 dichlorophenoxy acetic acid (2,4-D) and naphthalene acetamide (NAAm).

Gibberellins occur naturally in the seeds of many fruits (1, 2, 7) and in pollen of seedless grapes (8). One of the physiological functions of gibberellins from seed or from an external source is to induce fruit set (2, 5, 6, 7).

Although not isolated from date seeds, gibberellins are probably produced by date seed and aid in setting fruit. Unpollinated female date flowers sprayed with gibberellic acid (GA₃) should produce seedless fruit. GA₃ has been used successfully also to thin grapes (8). In the application of GA₃ to dates there might be the added advantage

of some thinning. Nixon (4) applied GA₃ to 'Medjool', 'Deglet Noor', 'Halawy', 'Khadrawy' and 'Barhee' date palms and found an increase in length of fruitstalks, an undesirable spiraling of fruitstalks, a premature shriveling of fruit, and an increase of blacknose of fruit. The second purpose of this work was to investigate further the effect of GA₃ on 'Medjool' dates.

MATERIALS AND METHODS

Six chemicals were tested in 1966 in a square block of 49 'Medjool' palms at the U. S. Date and Citrus Station, Indio, California. They were applied one, two and three weeks after the opening of the spathe at the following concentrations: 3,000 parts per million (ppm) DNBP; 500 and 600 ppm DNC; 20, 50 and 100 ppm 2,4-D; 20, 75 and 500 ppm 2,4,5-T; 50, 75 and 100 ppm NAA; and 50, 75 and 100 ppm NAAm. There were four replications, consisting of one bunch on each of four different trees. Half bunches were sprayed with a pressure-type hand sprayer. A piece of waxed paper divided the bunch in half during spraying and until the surface of the fruit was dry. There were three types of checks: (1) the unsprayed half of the treated bunch; (2) four bunches

on four different trees were thinned to 40 strands and each strand was thinned to 20 to 30 fruit; and (3) four bunches on four different trees were thinned to 40 strands but no fruit was thinned from the strands. The unsprayed side proved unsatisfactory as a check because there was an effect from the sprayed half, apparently because of translocation of the chemical or possibly a volatilizing effect.

GA₃ at concentrations of 25, 50 and 100 ppm was applied to pollinated and non-pollinated half bunches in the spring of 1966 within three days after normal pollination time. To avoid chance pollination, bunches to be left unpollinated were selected on trees on the windward side of the garden. Checks were the same as those described above. As explained above, the unsprayed half bunches could not be used as checks. The sprayed half bunches scheduled to remain unpollinated were covered with paper bags immediately after spraying and before pollination.

Because of the excessive fruit drop characteristic of ripening 'Medjool', I harvested the treated bunches when only 10 per cent of the fruit was mature. The remainder was in the late khalal² stage. Yields and fruit size were based on the fruit in the late khalal stage.

TABLE 1. The effect of various chemicals on size of fruit and weight per bunch of 'Medjool' dates.

Treatment	Concentration	Weeks after Pollination Treatment Applied	Av. weight Per bunch (khalal stage)	Av. fruit Per lb. (khalal stage)
	(ppm)	(no.)	(lbs.)	(no.)
DNBP	3,000	1	11 e ¹	18 b ¹
	3,000	2	12 e	18 b
	3,000	3	52 a	22 d
2,4-D	20	2	26 c	17 b
	50	2	14 de	15 a
2,4,5-T	20	2	26 c	18 b
	75	2	22 cd	15 a
NAA	50	1	12 e	17 b
	50	2	19 d	17 b
NAAm	50	1	10 e	18 b
Check ²			35 b	23 e
Hand-thinned ³		9	28 c	20 c

¹ Treatments having different letters are significantly different at the 5% level of probability.

² Check bunches were thinned to 40 strands, the same as all treated bunches.

³ Hand-thinned bunches were thinned to 40 strands and the fruit was thinned to 20-30 fruit per strand.

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² Khalal is the transition stage between green and mature fruit. The color of 'Medjool' fruit in the khalal stage is brownish yellow.

TABLE 2. Relation of seediness, size of fruit and bunch weight to pollination and gibberellin treatment of 'Medjool' dates

Gibberellic Acid Applied	Pollination Treatment and Checks	Av. weight Per bunch (khalal stage)	Khalal Fruit Per lb.	Seedless fruit on August 31	
(ppm)		(lbs.)	(no.)	Khalal (%)	Mature (%)
25	Pollinated ¹	8 de ²	23 c ²	64 a ³	1 b ³
50	Pollinated ¹	10 de	17 a	7 b	0 c
100	Pollinated ¹	12 bcd	20 b	45 ab	1 b
25	Unpollinated ⁴	8 de	26 c	81 a	96 a
50	Unpollinated ⁴	5 e	20 b	65 a	95 a
100	Unpollinated ⁴	6 e	29 c	94 a	99 a
0	Pollinated ⁵	36 ab	23 c	16 b	0 c
0	Pollinated, hand-thinned ⁶	28 b	20 b	0 c	0 c

¹ Pollinated 3 days before application of gibberellic acid.

² Treatments having different letters are significantly different at the 5% level of probability.

³ Treatments having different letters are significantly different at the 1% level of probability.

⁴ Unpollinated bunches were bagged and remained bagged for approximately 3 weeks.

⁵ Check bunches were thinned to 40 strands, the same as all treated bunches.

⁶ Hand-thinned bunches were thinned to 40 strands and the fruit was thinned to 20-30 fruit per strand nine weeks after pollination.

RESULTS AND CONCLUSIONS

Bunches treated with chemicals one week after pollination had larger fruit but a significantly lower yield than those hand-thinned (Table 1). The treatments removed too many fruit, probably because they interrupted fruit set.

Bunches treated with 20 ppm 2,4-D or 20 ppm 2,4,5-T two weeks after pollination had yields equal to those hand-thinned and significantly larger fruit (Table 1). However, 50 ppm 2,4-D, 75 ppm 2,4,5-T, 50 ppm NAA, 3,000 ppm DNBP and 50 ppm NAAM applied two weeks after pollination removed too many fruit, although the fruit produced were larger than those on hand-thinned bunches.

Treatments three weeks after pollination appeared to be too late for good results except for 3,000 ppm DNBP. This treatment nearly doubled weight per bunch as compared with those hand-thinned. Fruit, however, were smaller than those on the hand-thinned bunches but larger than those on the bunches not hand-thinned. DNBP evidently inhibited post-bloom drop.

Bunches in treatments not appearing in Table 1 had poorer yields and smaller fruit than the checks.

In the GA₃ treatments, bunches pollinated and sprayed with 100 ppm, those unpollinated and sprayed with 50 ppm, and the pollinated, hand-thinned checks had fruit of equal size. Pollinated bunches sprayed with 50 ppm had significantly larger fruit (Table 2).

Unpollinated bunches sprayed

with GA₃ had a significantly higher percentage of seedless fruit in both the mature and the khalal stage than did the checks (Table 2).

Pollinated bunches sprayed with 25 ppm or 100 ppm had large numbers of seedless fruit in the khalal stage. Pollinated bunches sprayed with 50 ppm had a few seedless fruit, but there was no significant difference from the non-hand-thinned checks. The large size of fruit on pollinated bunches sprayed with 50 ppm of GA₃ may be accounted for by the combined effect of the GA₃ and the seeds they contained as a consequence of pollination.

SUMMARY

Six chemicals were applied to 'Medjool' date bunches at various concentrations one, two and three weeks after pollination to test their effectiveness as fruit thinners. GA₃ at various concentrations was applied to pollinated and unpollinated bunches to determine its effect on production of seedless dates and to test it as a chemical thinner.

Applications of 20 ppm 2,4-D and 20 ppm 2,4,5-T two weeks after pollination thinned the fruit without decreasing the weight per bunch below that of the hand-thinned.

GA₃ at suitable concentrations on pollinated bunches produced larger fruit than on checks and on unpollinated bunches produced fruit equal in size to that of the checks.

GA₃ applied to unpollinated bunches produced seedless dates. The same application to pollinated bunches produced some seedless

dates but significantly less than when applied to unpollinated bunches.

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MALATHION, A FACTOR IN DATE HARVESTING

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Mechanization in California of all phases of date culture, particularly in harvesting, has increased at a rapid rate the past few years. These new fruit harvesting methods have caused some pest control problems that formerly were only occasionally of economic importance. During 1966 in some areas of the Coachella Valley, the nitidulid beetles, or sour bugs, and the two phycitid moths, the Indian-meal moth and the raisin moth, caused more than a normal amount of injury to date fruit before it reached the packinghouse. Additionally, the conditions best suited for mechanized harvesting are ideal for infestations of the saw-toothed grain beetle.

A delayed harvest is necessary for the best results in mechanized harvesting (3). However, dates that are not picked as they become ripe are quite susceptible to nitidulid beetle infestations. After ripening they become dehydrated in the bunches and dry fruit are ideal for both the phycitid moth and the saw-toothed grain beetle.

Detailed information on the life history and habits of these insects has been reported in the literature. Four species of nitidulid beetles infest dates in California: the corn-sap beetle, *Carpophilus dimidiatus* (Fab.); the dried-fruit beetle, *C. hemipterus* (L.); the pineapple beetle, *Urophorus humeralis* (Fab.); and the yellowish nitidulid, *Haptoncus luteolus* (Er.). The corn-sap beetle is the predominant species, but any of the other three may occasionally be found in large numbers. When dates are not present these beetles infest many kinds of decayed vegetation adjacent to date gardens. The adults fly from surrounding grapefruit groves, truck crop fields or vineyards into the date gardens during the June fruit drop period and infest the dates on the ground and in the bunches. A single female may oviposit from 500 to 1000 eggs on the fruit skin. The larvae enter the fruit through cracks in the skin or through the calyx end, preferring ripe dates, but when large populations exist they will infest any fruit and feed on the pulp until ready to pupate (approximately 2 weeks). The larvae then drop to the ground and pupate in the soil. Life cycle time from egg to egg varies with temperature, humidity and the nitidulid species, but is

generally from 16 to 27 days.

The raisin moth, *Cadra figulilella* (Greg.), not only resembles the Indian-meal moth, but its injury to dates is almost identical. It feeds on the date pulp and prefers the dry fruit. The life cycle of the raisin moth under optimum conditions is about 43 days. The females oviposit from 350 to 700 eggs.

The Indian-meal moth *Plodia interpunctella* (Hbn.), although not as prolific as the raisin moth, is usually more numerous in date gardens. The females, like the raisin moth, deposit their eggs on the fruit skin. After hatching, the tiny larvae enter the fruit through cracks in the skin, at the calyx end or by chewing into the healthy fruit. They feed on dry fruit and may feed on the hard date seeds. They leave large masses of frass and silken threads inside the fruit, making the dates inedible.

The saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.), is listed in most publications as a pest only on stored products, but there have been some unpublished reports of severe injury by this beetle to dry dates while in the bunches. They attack the dates in the same manner as the phycitid moth and have a life cycle, egg to egg, from 27 to 315 days. Some adults in captivity lived for 3 years. The female beetles may oviposit from 45 to 285 eggs.

Lindgren and Vincent, (2), found that malathion dusts were effective in the control of nitidulid beetles and phycitid moths in date bunches. Their extensive laboratory screening program established that lindane, chlordane, aldrin, dieldrin, heptachlor, parathion and malathion were the most effective insecticides then available in reducing populations of these pests. Field test plots with these compounds indicated that parathion, dieldrin and malathion were the most promising. Because malathion is the least toxic to warm-blooded animals and did not impart any off-flavor, it was selected as the candidate insecticide for registration and use on dates.

Malathion was the first and is still the only insecticide registered for use on dates. Results of numerous experiments and commercially applied treatments in date gardens have established that a 4% malathion dust is effective in reducing injurious nitidulid beetle

and phycitid moth populations provided the dust is thoroughly applied to the entire bunch approximately 3 weeks before the first fruit is picked. A close inspection of the bunches after the fruit ripens is necessary to establish a need for re-treatment. Successive dustings at regular intervals may be necessary if these insect pests continue to fly in and infest the bunches after the toxic effects of the first malathion dust have dissipated. Additional field evaluation on the toxic longevity of malathion is needed under the extreme climatic conditions found in date growing areas to determine the frequency of control applications. With the increased use of mechanized fruit harvesters and the delayed harvest that is necessary for economical mechanical pickers, an even more carefully controlled use of malathion is necessary.

Laboratory tests were conducted to determine the resistance level of the phycitid moths and nitidulid beetles to malathion. Populations of the corn-sap beetle and the Indian meal moth were collected from 8 different localities in the Coachella Valley. These populations were maintained separately in the laboratory and were exposed to various dosages of malathion for various periods. There was no evidence that resistance to malathion occurred in these local populations. Excessive damage to field fruit therefore must be due to inadequate coverage by existing mechanical dusters or to improper timing of multiple dust applications.

Malathion may also be applied as a spray with a conventional high pressure citrus sprayer and spray guns capable of reaching the higher date bunches. Malathion spraying was first tested on soft date varieties on which dust deposits are not desirable (1). This application method produces no better control than dusts when dusts are applied under ideal dusting conditions, but during windy conditions better coverage of the higher bunches can be achieved. Sprays should be applied at the rate of approximately 5 gallons per tree using 2 pounds of actual toxicant malathion per 100 gallons of water. As with dusts, more than one spray may be needed if reinfestation occurs.

Mechanized harvesting appears to be a solution to date labor problems, but in order to have a crop

to harvest, the pests, briefly described here, must be kept at sufficiently low numbers to prevent excessive injury to the fruit. Malathion continues to give adequate protection when used properly, and because of the high cost of registering new insecticides for use on

crops, it should be used for maximum benefit.

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DATE CULTURE IN SUDAN

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The Government of Sudan, through the U. S. Agency for International Development (AID), asked me to visit their country from November, 1965 through January, 1966 to advise the Horticulture Section, Ministry of Agriculture, in promoting more profitable date production. My visit followed the date harvest, but I saw samples of dry or dried fruit of all the principal varieties. Although I did not see cultural operations done at other seasons, from observations in many typical date plantings and conversations with date growers and government officials, I got a fair idea of the present status of date culture².

GEOGRAPHY

Sudan is the largest country in Africa, about the size of the United States east of the Mississippi. It extends from north to south about 1200 miles between latitudes 22° and 4° north and from west to east about 1000 miles. It is bounded on the north by Egypt, on the east by the Red Sea and Ethiopia, on the south by Kenya, Uganda and Congo, and on the west by the Republic of Central Africa, Chad and Libya. It is a country of vast plains broken by widely separated hills or mountains. Approximately the northern third is desert, changing gradually through areas of steppe and savanna to the equatorial region, which stretches across the extreme south and includes large marshes and extensive forests. The Nile cuts across Sudan from south to north and is the most important natural resource of the country.

DATE AREAS

Location: About 95 percent of the date palms in Sudan are grown along the Nile between the Egyptian Border and Khartoum, some 600 miles to the south. The few scattered oases elsewhere are of minor importance. The numbers of mature palms in the different areas from north to south, estimated from the 1960 census, are listed in Table 1.

In number of palms, Wadi Halfa was the most important area in 1960. Since then, however, the rising water of Lake Nasser behind the Aswan Dam has flooded Wadi Halfa village and the palms around

TABLE 1. Estimated number of mature date palms in Sudan.

Area	Number
Wadi Halfa	766,314
Dongola	497,817
Merowe	701,064
Berber	384,996
Shendi	72,455
Khartoum	6,536
Total	2,429,182

it. When the lake reaches its maximum size in 1967, it is estimated that 372,749 fruiting palms will be covered. This reduction in palm population is believed to have been more than offset by subsequent plantings. According to Government estimates, during 1961-63, 447,000 offshoots or nursery palms were planted in other areas. Of these, 295,000 were planted in the Merowe area and would make it the most important in Sudan. If these recent plantings are included, the number of palms in 1965, excluding those being flooded by Lake Nasser, was at least equal to that reported in the 1960 census.

Production: Date production, as reported at the Second International FAO Date Conference in 1965 (1), is estimated to range from 45,000 tons to 60,000 tons. The Foreign Trade Statistics Annual of the Republic of the Sudan lists the exports and imports of dates (Table 2). Exports, mostly to Egypt, dropped in 1963 and 1964 because of political and economic problems which were said to have been largely solved in 1965 and subsequent exports are expected to approach earlier figures. Imports have usually been in excess of exports.

TABLE 2. Exports and imports of dates—Sudan.

Year	Exports (thousand pounds)	Imports (thousand pounds)
1964	339	8,586
1963	2,958	10,984
1962	4,594	8,448
1961	5,500	5,139
1960	6,129	8,221

Climate: In Table 3 are climatic data for stations along the Nile where dates are grown from Wadi Halfa near the Egyptian Border to Khartoum. For proper maturing of fruit the date palm requires a long, hot growing season without rain or high humidity during the ripening period. There is ample heat in all parts of Sudan where date palms occur. Average maximum temperatures are actually higher than those in three other areas where commercial date culture is highly developed. About 80 percent of the dates in world commerce are produced in the Basrah area. Touggourt, in the Oued Rhir of Algeria, is the home of the famous Deglet Noor, one of the world's finest export dates. Indio is the center of California's small, but well-developed date industry, where cultural practices and fruit processing have been advanced to a high point. These other date-growing areas have greater extremes of temperature as is evident from the highest maximum and the lowest minimum temperatures. Freezing temperatures occur every winter and, at least at Indio, are occasionally low enough to cause serious damage to date palms (7, 8). In Sudan, on the other hand, no freezing temperatures have been recorded and that is why mangoes, bananas and other tropical fruits can be grown.

According to Mason (4) the Dongola-Merowe (Kareima) region has the "highest mean temperatures and the lowest relative humidity of any successful date region in Africa." Nevertheless, summer rains, which increase in Sudan from north to south, occasionally invade the date areas. Serious rain damage was recorded in 1950 and in 1958; all growers questioned were familiar with it and had observed differences in the amount of damage sustained by the different varieties.

The rainy season in Sudan comes just before and during the date harvest, which for most varieties is late August through September. As a consequence, in spite of the lower total rainfall, the average for the July - October period in the Dongola - Kareima area is greater than that of Basrah, Touggourt, or Indio. South of Athara the increase in rainfall makes dates less profitable than other crops, so this is

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TABLE 3. Climatic data for stations in Sudan compared with those of other important date-growing localities.

	Air Temperature (°F)					Average Rainfall (Inches)		
	Average Daily Maximum			Extreme				
	No. Yrs. Record	May-Oct. Incl.	Annual	Maximum	Minimum	No. Yrs. Record	July-Oct. Incl.	Annual
Wadi Halfa	30	104.4	94.5	120	34	24	0.08	0.12
Dongola	16	106.9	98.4	119	37	30	0.86	0.91
Kareima	30	106.8	99.1	118	38	25	1.46	1.50
Abu Hamed	18	106.8	98.8	118	41	30	0.63	0.67
Atbara	30	105.7	99.7	118	44	30	2.61	2.83
Shendi	19	102.0	98.9	115	44	30	5.15	5.35
Khartoum	30	102.5	99.1	118	43	30	5.94	6.46
Basrah, Iraq	19	99.4	84.9	127(a)	25(a)	20	0.14	6.42
Touggourt, Algeria	15	96.6	83.4	122(b)	27(b)	16	0.31	2.27
Indio, California	45	99.7	88.5	125(c)	13(c)	73(c)	0.85	3.20

(a) 11 years record (2)

(b) 10 years record (2)

(c) 54 years record (U. S. Weather Bureau)

about the limit of commercial date culture. The few early-ripening soft dates grown around Khartoum are marketed in the early stages of ripening and even then rain damage frequently occurs. It is evident that in Sudan the distribution of rainfall rather than the amount limits date culture.

VARIETIES

About 98 percent of the dates grown in Sudan are either dry or semidry handled as dry. The climate of the commercial date areas, discussed above, and the cultural practices mentioned later all favor the production of dry dates. These conditions and the fact that excellent dry varieties are already well established justify Tothill's conclusion (12) that "the future prosperity of the Northern Province depends on accelerated and improved propagation, grading, and marketing of good dry dates." However, a ready market for the few soft dates produced has encouraged some further plantings of the best of these.

Aweis (1) stated that 30 varieties of dates are grown in Sudan, but named only 4. I found 20. Dowson (2) listed the same number, but 6 are different from any on my list. However, fewer than 10 varieties are widely grown and only 2 of these are likely to be found out of season in most markets. One of the two, Barakawi, accounts for about 40 percent of the palms and the other, Gondeila, for about 5 percent. As about 40 percent are seedlings, this leaves only some 15 percent of miscellaneous minor varieties.

Barakawi is the outstanding variety grown in Sudan. According to

Mason (6), "the Barakawi of Sukkot and Dongola, known down the river as 'Sukkoti', but more commonly as 'Ibrimi', is perhaps the world's all-round best dry date." Offshoots of Barakawi have been continuously in demand and it is the principal variety planted on the government schemes where only those recommended are permitted. It is generally agreed that it has the best keeping qualities of all varieties in Sudan. It is said to keep well for two years and to be so hard that weevils do not get into it. It is a favorite among the nomads and is the one variety that has long been exported to Egypt.

Mason (6) found great variation among the dates sold as this variety in Egypt and was told in Dongola that the crop from seedling palms bearing fruit closely resembling the original variety is marketed under the name of Barakawi. This emphasizes the need for varietal study to determine the true type and make sure that it is recognized and propagated rather than similar but inferior seedlings.

Gondeila is the second most important variety of Sudan. The fruit is found in most markets and there are at least a few palms in nearly all localities where dates are grown. For eating, Gondeila is preferred to Barakawi and, in markets that I visited, was sold at prices 25 to 50 percent higher. Gondeila is commonly treated as a dry date, but it is not as hard as Barakawi and, if harvested just as it reaches maturity and before drying, it can be handled as a firm soft date.

Gondeila has several drawbacks. It does not keep well, an unattractive darkening occurs in storage, and it is very susceptible to insect infestation (10). Most of the Gon-

deila fruit, even when handled as a firm soft date, retains some drier areas at the base which are lighter in color than the apical portion and produce a somewhat mottled appearance in a pack. This drawback of the Gondeila appears similar to that of the Halawy, one of the principal export dates of Iraq and also grown in the United States. The large percentage of dry bases, characteristic of that variety, has been shown to be greatly reduced by increased irrigation during early summer (3).

Bentamoda is regarded by most people who know it as the best date in Sudan, but it is only about 2 percent of the palm population, most of which is in the region between Dongola and Wadi Halfa. According to Mason (6), "it's superb character as a dessert fruit, with its admirable keeping and shipping qualities, entitle it to a high place among the world's finest dates." It is a semidry date of about the same type, size and shape as the famous Deglet Noor, but I did not see in Sudan any fruit of Bentamoda that would equal the best Deglet Noor produced in Algeria, Tunisia and California.

Deglet Noor, known in Sudan as "Tunisie", is represented by a few specimens brought in as offshoots in 1910 (5). At Nuri I examined 11 palms that were 10 to 30 feet high. A few others are said to occur in private gardens in the Merowe and Dongola areas, but no apparent effort has been made to propagate the variety. All the fruit samples that I saw were small, inferior, dry dates, not equal to the best of Bentamoda. The very dry climate and lack of thinning may have been partly responsible, but

a more obvious explanation is the heavy soil which was dry and under-irrigated, as indicated by crowns with only 30 to 60 good green leaves. Mature Deglet Noor palms in California, well watered and fertilized, carry 100 to 120 good green leaves (9).

Mishrig Lagai is the most popular soft date grown commercially in Sudan. Its texture and quality are comparable to the best of the soft dates of Iraq. The cured date is reddish brown in color with skin adhering to the flesh and tending to shrink in attractive jewel-like facets, resembling in this respect the Amir Hajj of Iraq. Its chief drawback for marketing, according to American standards, is its small size. As it has large bunches similar to those of Khdrawy, size could undoubtedly be improved by thinning the bunch as is done in California.

Mishrig Khatib is a date of about the same size and shape as Mishrig Lagai, but the flesh is a little firmer and not quite as smooth in texture, the skin separates badly in curing, and the seed is larger. It is always rated below Mishrig Lagai in quality, but has been planted even more extensively than the latter, partly perhaps because of its availability. The variety produces many offshoots; 30 to 40 are not uncommon and they root more easily than those of any other variety. Apropos of this, there is a saying, which I heard in several places, to the effect that if a man takes a freshly cut offshoot of Mishrig Khatib from the palm where it was cut to the place where it is to be planted, he must run or it will take root on his shoulder.

Kulma is the largest date I saw in Sudan, but there are said to be only a few hundred palms. According to Tothill (12), it can either be dried or be made into an excellent soft fruit. The only specimens I examined, however, were not very prepossessing, being semidry to dry with coarse, fibrous flesh, in which were some rather tough portions.

Medina is the earliest-ripening variety in Sudan. It is handled and consumed almost entirely as a fresh soft date and it may be in local markets by July 1 or earlier. I did not see any of the fruit, but it is highly praised.

CULTURAL PRACTICES

Offshoot Handling: The most favored time for cutting and planting offshoots in Sudan is August when the Nile is nearing its highest stage. February may be a second choice, but there are some differences of opinion and in a country where frosts are unknown the exact time is less important than the availability of water and proper care. The California type chisel introduced by Mason (5) is now be-

ing used, at least in the Government projects. More leaves are usually cut from the offshoot than in California, the outer ones being removed and 3 to 5 in the center being cut back to 1 to 2 feet from the bud. Offshoots are protected from the sun and wind for the first season after planting by a cone of date leaf sections with the lower ends of the midribs anchored in a radius of about one foot from the offshoot and the tips tied together just above the top of the offshoot. Wraps of date leaves, fiber, or other leafy material attached to the offshoot, common in other date-growing countries, are said to encourage termite damage. Offshoots from dry, or under-irrigated, palms are preferred for planting, and more than once I noticed lush growing, old palms near the river with most of their offshoots left, whereas those farther away and higher and drier had most of their offshoots removed.

Spacing: The Government has for many years recommended a spacing of 8 x 8 meters. This spacing with single stem culture is being used on the Government projects. However, in the old date gardens palms are more closely spaced and it has been the practice to leave several offshoots on each palm, forming in time a clump of several large stems. The average number of stems might be 3 or 4 per clump, but it is not uncommon to find a clump with a dozen or more. These closely spaced palm clumps are what one sees all along the banks of the Nile. In some places, date palms occur as a narrow fringe, sometimes only one or two palms wide, and obviously suffer excessive exposure to wind and sun and occasional erosion by the river in flood. Under such conditions multiple stems, or stooling, may be advantageous and this may be one explanation of the origin of the practice. However, there is reason to believe that in regular orchard plantings away from the river bank, as all the Government projects are, the recommended wider spacing and single stem culture are better. According to Sayed Atabani, data obtained at the Nuri Station showed that single stem plantings produced higher yields and better quality than multiple stems. Of course, in the use of tractors, spray rigs, or other heavy equipment, stooling, with many stems inevitably leaning at various angles, is a serious drawback.

Interplanting of dates with citrus, mangoes and other fruit trees is not being recommended. However, beans and other low-growing crops are often interplanted, especially among young palms. Offshoots are frequently started and do well in plantings of berseem.

Irrigation: That newly-planted offshoots require small amounts of water at frequent intervals is everywhere recognized. In Sudan water

is applied every 2 or 3 days for the first 2 or 3 months, with somewhat longer intervals after that. Soil type determines the most desirable interval, which may vary from daily on very sandy soil to 5 or 6 days on very heavy soil. Once well established, date palms are seldom irrigated for themselves, but are benefited by water given to other crops grown between them.

The oldest, and formerly the most common, method of obtaining water from the river for irrigation is the sakieh, which raises it by an endless chain of earthen pots attached to a pair of ropes. Propulsion is usually provided by one or two oxen pulling around the outer end of a long pole which transmits power by three great, geared wooden wheels. The sakiehs, a picturesque sight all along the Nile often mentioned by travellers, are gradually being replaced by pumps in Sudan. Large pumping installations provide water for all the Government projects and I was impressed by the large number of abandoned sakiehs between Merowe and Dongola. In that region at least the creaking of sakiehs was heard less often than the chugging of gasoline engines.

Fertilization & Cultivation: Mature date palms in Sudan are seldom fertilized. Only when fertilizer is applied to some crop grown with them do the palms get any at all. Manure is sometimes applied to individual "sick" palms with beneficial results. Weeds may be kept down by hoeing for some years until the palm is well established, but no other tillage appears to be done.

Pruning: The only pruning is the removal of dead leaves, usually in the fall. Instead of being trimmed close to the trunk, as in most of the date-growing countries of the Old World, the long leaf petioles are left. The tree climber uses these petioles to ascend the palm without a girdle. The fact that they can be used for this purpose is evidence of a very dry climate, for if the humidity and rainfall were higher some of them would soon rot.

Pollination: For pollination 3 or 4 strands of male flowers, or sections of strands cut or bent to a length of 4 or 5 inches, are tied in a little bundle with a piece of fiber from the spathe or a leaflet and the bundle is wedged in between the strands of the newly-opened female flower cluster without the bother of tying.

In Sudan pollen is commonly stored for possible use the first of the next season if fresh pollen is not available. Little bundles of male flowers used for pollination are said to be placed in baskets and put in a dark, dry place, suspended sometimes from the ceiling of a storeroom. Apparently it is seldom necessary to use this old pollen, but

all persons questioned said that it was not as good as fresh pollen.

Variations among male palms as to time of flowering and the production and effectiveness of pollen have been observed, and offshoots of selected males are preferred to seedlings, but there are no generally recognized varieties of males.

Fruit Thinning: In Sudan fruit is seldom thinned. Furthermore, no one complained of alternate bearing. This is a rather surprising situation in view of the well-known behavior of the date palm under cultivation. Possibly some alternate bearing is not recognized because no individual palm records are kept and all palms are not in the same cycle so that it does not show up in total yield per garden. A more likely explanation is that under conditions most common in Sudan (no fertilization and usually less water than required for maximum production) a palm does not produce enough bunches to reach or exceed its maximum productive capacity. This explanation is suggested by one informant on Margasi Island who said that a palm without water would produce 8 bunches, with water 18 to 24, but if 18 were produced one year there would be only 12 to 14 the next.

Bunch Management: Apparently little or no attention is given to the bunches after pollination. Occasionally, when the fruitstalks have about reached their maximum length, the bunches may be placed to straddle leaves or pulled down below them and supported by forked sticks or by tying to leaves above. Bunch handling of the few soft dates grown seems to be given more attention than that of the dry dates.

FRUIT HANDLING

The dry dates of Sudan are harvested by cutting the ripe bunches and dropping them to the ground where the fruit is stripped from them and carried to some court or compound to be prepared for market. For further drying and temporary storage the dates are spread out to a depth of one or two feet. In one such compound, which I visited in December, the fruit was being turned by two men; one held a wooden implement shaped like a shovel and the other pulled a rope attached to the handle just above the blade in a kind of plowing operation. The turning was said to be done about once a week to promote uniform drying and to discourage termite attack. Fruit may be held this way from 2 or 3 weeks to 2 or 3 months, depending on variety, season and marketing conditions. It is then baged in 70kg. (154 lbs.) burlap sacks. During November and December I saw hundreds of these sacks stacked along the banks of the Nile awaiting shipment.

The fumigation of dates has been encouraged by the Kareima Packing House (13), but I was told that still relatively few are so treated. One merchant in that vicinity showed me his dates stored under a tarpaulin used for fumigation somewhat as in Coachella Valley.

Between Dongola and Wadi Halfa near the native huts one frequently sees large earthenware jars ("qusaibas") used for storing dates or grain. Shaped somewhat like a Mexican olla except that they are a little broader at the top, they vary from about 3 to 6 feet in height. A flat circular slab, sealed at the edges with clay, covers the opening at the top. This may be taken off and resealed, as the owner of one demonstrated; or a hole may be cut in the side near the bottom and then closed with fresh clay. In the one opened for my inspection the dates were mixed with ashes for insurance against the spread of insects from any infested fruit that might be included. The fruit, of course, is not fumigated before being placed in the storage jar.

PESTS

Parlatoria, or white date scale (*Parlatoria blanchardi* Targ.), was found on date leaves in all localities, but, with one or two exceptions, was never abundant enough to cause any concern. Most of the scales examined appeared to have been parasitized. However, according to the Horticulture Section of the Ministry of Agriculture, infestations are often serious enough to warrant treatment. "Rogor" (dimethoate) applied during November and December was said to give fairly good control.

Red date scale (*Phoenicococcus marlatti*, Kll.) was found on small offshoots that had recently died in nurseries and were dissected for diagnosis. Red date scale is widespread in the date-growing countries of the Middle East and occurs on all imported varieties in California. It occurs mostly behind the overlapping leafbases, where it is protected from high summer temperatures. When palms are in a healthy growing condition it does not appear to do any appreciable damage, but occasional injury to small offshoots in nurseries has been reported (11).

Termites, or "white ants", were said in many places to be the most destructive pests. I saw a number of palms with their protective encrustation all along the trunk, covering the fiber and leaf axils up to the bud itself. I was told that termites eat living palm tissue and are responsible for severing fruitstalks, thus causing fruit to shrivel before it ripens. I saw old fruitstalks that had obviously been severed by some insect. In one instance a clump of 4 Barakawi stems, 20 to 30 feet high, showed serious injury, apparently from termites. One stem was already dead and adventitious

roots, which extended 5 or 6 feet up the trunk, were completely plastered with termite covering carried on to the trunk fiber above, while another stem in a declining condition was infested in the same way. The extent and prevention of termite damage should be investigated.

Red ants about one centimeter long, seen in large numbers on the roots of a few palms, were said to be causing damage.

Date mite (*Paratetranychus afraasiaticus* McGregor), under a former name, *P. simplex*, was reported in Sudan by Tothill (12). Of the many samples of fruit I examined in different gardens, very few showed evidence of this pest.

Rats were reported to cause considerable loss of fruit in a number of places, particularly where large clumps of old palms with long leaf stubs formed ideal places for their nesting and movement.

The saw-toothed grain beetle (*Oryzaephilus surinamensis* L.) and larvae of *Ephestia* are two insects mentioned by Tothill (12) as attacking dates in storage. I found a few specimens of what I took to be both pests in samples of fruit at different places. In markets visited the percentage of bulk dates showing evidence of insect infestation was high.

DISEASES

No evidence of any serious disease affecting date palms was found in Sudan. Occasionally I was shown a single dead or dying palm, but in no instance any trouble that appeared to be spreading or affecting other palms.

Near Kareima I saw one palm with symptoms said to be possibly the "El Arkish" disease, rare in this locality but more common in Wadi Halfa. The affected palm was of the Kulma variety, 9 years old and 5 feet high to the bud. The symptoms had begun to appear four years earlier. Pinnae were dying at the tips of the leaves and the tips of pinnae were dying along the midrib for about $\frac{1}{3}$ or $\frac{1}{2}$ the length from the outer end, giving the palm a "ragged" appearance. White, or chlorotic, streaks frequently extended longitudinally down the sides of green pinnae with a sharp line of division between green and white. Where the white area was beginning to die, the adjacent green was yellowish, often a stippled yellow at first, then solid yellow. There were several offshoots on this palm and the newly emerging leaves on all of them were affected. Palms nearby were all in a healthy condition and the gardener knew of no other palm in the vicinity with similar symptoms. One other palm near Kulud, of the Barakawi variety, about 10 feet high and said to be 19 years old, showed somewhat similar symptoms, but only 1 of 3 small offshoots showed the dying

back of leaf and pinnae tips like those of the parent palm.

Specimens of affected tissue from both palms were sent to Dr. J. Louvet, Chief of Research, Station Centrale de Pathologie Vegetale, Versailles, France, who has been studying the bayoud disease in Morocco. Dr. Louvet found no organism on the specimens of Barakawi, but isolated a fungus, *Fusarium moniliforme*, from those of Kulma. As this fungus has not been observed on the date palm, Dr. Louvet questioned whether it caused the damage. If these two palms have symptoms that are typical of the so-called "El Arkish" disease, it is apparently a slow decline, and its rare and isolated occurrence gives no cause for alarm.

EXPERIMENTAL WORK

At Nuri, a few miles up the Nile from Merowe and Kareima, is a 50-acre tract where for many years field tests were conducted with methods of irrigation, fertilization, interplanting, spacing, offshoot removal and fruit handling. The principal varieties grown in Sudan are all found there and in single stem plantings. Some recommendations of the Horticulture Section of the Ministry of Agriculture have apparently been based on work done at this station. At the time of my visit, however, it was being operated on a maintenance basis and I was unable to locate any publications or records of work done.

At Hudaiba, near Athbara, a new experiment station has been established where laboratory facilities are being provided and a research staff is being built up. Work has been started on citrus and vegetable crops and some is contemplated with dates, but the climate there is less favorable for date culture than at Nuri.

A modern date packing house has been in operation at Kareima since 1959. It was built and operated for several years under the direction of Frank Winter from Coachella Valley working under the Food and Agriculture Organization of United Nations (13,14). This packing house is equipped for fumigation, cleaning, grading and packing of dates, and does packaging similar to that done in California. By-products such as syrup, vinegar and alcohol are being produced on an exploratory scale. The varieties handled are Gondeila, Bentamoda, Mishrig Lagai and Mishrig Khatib (1). The packing house has done much to stimulate interest in better methods of fruit handling.

PROBLEMS

Offshoot Survival: Following the recommendation of Mason (5), government nurseries were established to aid date growers in obtaining offshoots of the best varieties by making them available at reasonable prices through selection,

careful cutting and growth in nursery before distribution. These nurseries have been serving the purpose for which they were established, but offshoots have never survived as well as they should. So far as I could learn, except for one variety, Mishrig Khatib, survival has never been as high as 90 percent and seldom above 75 percent.

In 1963 and 1964, according to the Ministry of Agriculture, some 86,000 date offshoots were removed from the Wadi Halfa area to save them from flooding by rising water behind the Aswan Dam. Most of them were Barakawi with a considerable number of Gondeila and Bentamoda, the best varieties grown commercially in Sudan and all in constant demand for planting. The offshoots were planted in 6 different nurseries. It is estimated that less than 8 percent of them survived. This represents a tremendous loss and was a matter of much concern in the Ministry of Agriculture. Lake Nasser in 1965 was only about half the depth expected after the completion of the dam, and it was estimated that along the river above Wadi Halfa perhaps as many more offshoots as were previously cut could be salvaged if removed in 1966.

I visited all the government nurseries (Gureir, Kulud, Gabha, Dongola, Borgeig and Bauga), made detailed examinations of conditions and discussed with various officials involved the manner in which the Wadi Halfa offshoots were handled and the methods regularly employed in the different nurseries. The results with offshoots from Wadi Halfa were the same in all of them. Yet offshoots of the same varieties obtained from local government schemes and planted in June and July, 1965 were surviving about the same as usual with varying results in different places. This indicated that handling in the nurseries was not primarily responsible for the high mortality of the Wadi Halfa offshoots.

All evidence indicated that the extremely poor survival of Wadi Halfa offshoots was due primarily to the length of time that elapsed between cutting and planting (as much as 30 to 40 days) and the high temperatures to which they were exposed during this period. For 5 days the offshoots were enclosed in a metal railroad car. Unfavorable conditions, which to varying degrees in the different nurseries may have contributed to the low survival of offshoots, were: heavy soil, grass and weed growth, small offshoots planted too deep, failure to prune back long roots, and red date scale (11).

Wind Damage: In July, 1965 an estimated 5000 date palms in the Gurier Scheme alone were blown down by a single wind storm. Many still lay where they had fallen. Others had been split into quarter sections lengthwise and were stacked up drying for use as timber. No

part of the date palm goes to waste. Numerous palms were propped with poles to prevent falling. Wind damage is apparently an occasional hazard that must be reckoned with in the date-growing areas of Sudan. I have not seen or heard of anything quite like it anywhere else in the Middle East, but similar damage on a much smaller scale has occurred in the Coachella Valley of California.

Date Grades: A system of grading is needed in the marketing of bulk dates in Sudan. In the same lot will be found dates of all sizes and conditions, along with broken, mashed, or dirt-covered fruit. There is much evidence of insect infestation. That the public might accept some grade standards is suggested by the fact that the merchants themselves set different prices for different lots of bulk dates that obviously vary in average quality. In the date market in Omdurman I saw one merchant taking out the largest and best dates from a sack of Barakawi. When asked what he would charge for the two lots he was separating, he said 40 piasters a ruba (11 lbs.) for the selected Barakawi, 24 piasters a ruba for the others. Fumigation would be a prerequisite to grading and better storage would be encouraged, thus reducing insect infestation, which is a source of considerable loss.

Trained Personnel: Sudan has made considerable progress since its independence in 1956, and there are dedicated, well-trained men in Government service, some with advanced degrees from American universities, but, in agriculture at least, there is great need for more men with good scientific educational background combined with thorough knowledge of the crops grown and some experience in handling them. If a trained expert in date culture had been responsible for the removal of offshoots from Wadi Halfa, the almost total loss of transplanted offshoots probably would not have occurred. Perhaps this lack has kept the Nuri Station from being more effective in testing and adapting to local conditions cultural practices already proved by research and experience elsewhere to be of value in improving the growth and production of date palms. With trained personnel backed by a stable government, there should be a good future for date culture in Sudan.

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PROGRESS REPORT: CHEMICAL AND HISTOLOGICAL STUDIES OF TOUGH AND TENDER 'DEGLET NOOR' DATES¹

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Tough (dry) 'Deglet Noor' date fruit have been recognized as a problem for many years in the California date industry. Rygg (5) reported that it is not uncommon for as much as 30 per cent of the crop to be dry enough to require hydration. His report, that dry grades represented 80 to 90 per cent of the 1947 crop, indicates that the problem occurs in a more severe form in some years.

Methods of grading dates rapidly and accurately and faster, more reliable methods of converting tough dates into tender products are needed to realize the full benefit of recent and anticipated advances in mechanization of harvest and packing operations.

The problem of tough dates is being investigated at the Riverside Campus of the University of California under financial support from the U.S. Department of Agriculture. The general research plan is (1) to determine the significant chemical and histological differences between tender and tough Deglet Noor dates and (2) to use chemical and histological differences as a basis for research on tenderization of the tough grades. This report describes some recent chemical and histological comparisons of firm and soft date fruit tissue.

CHEMICAL STUDIES

Number 1 dry (tough) and natural (tender) dates obtained from the 1965-66 crop and the 1966-67 crop, as well as fruit of different stages of maturity from the 1966-67 crop, have been subjected to analyses for moisture, reducing sugars, sucrose, pectin fractions, lignin, hemicellulose fractions and cellulose. All data, except for moisture, have been evaluated as per cent composition on a dry weight basis.

Studies by paper chromatography and thin-layer chromatography indicate that sucrose, glucose, and fructose were the only soluble sugars extracted from the tissue. Reducing sugars (glucose and fruc-

tose) were present in relatively low concentrations from kimri (turgid and green) to khalal (turgid and red) stages of maturity, but increased sharply from the first stage of softening to the tree-ripe stage. Sucrose levels increased to a high point at approximately the half-khalal stage and then decreased as the tree-ripe stage was approached.

These data are in close agreement with results reported by Rygg (4).

Number 1 dry fruit had a lower moisture content, a higher sucrose level, and a lower amount of reducing sugars than the lots of natural fruit. Approximately the same level of total sugars was found in the two grades. These results are in good agreement with reported

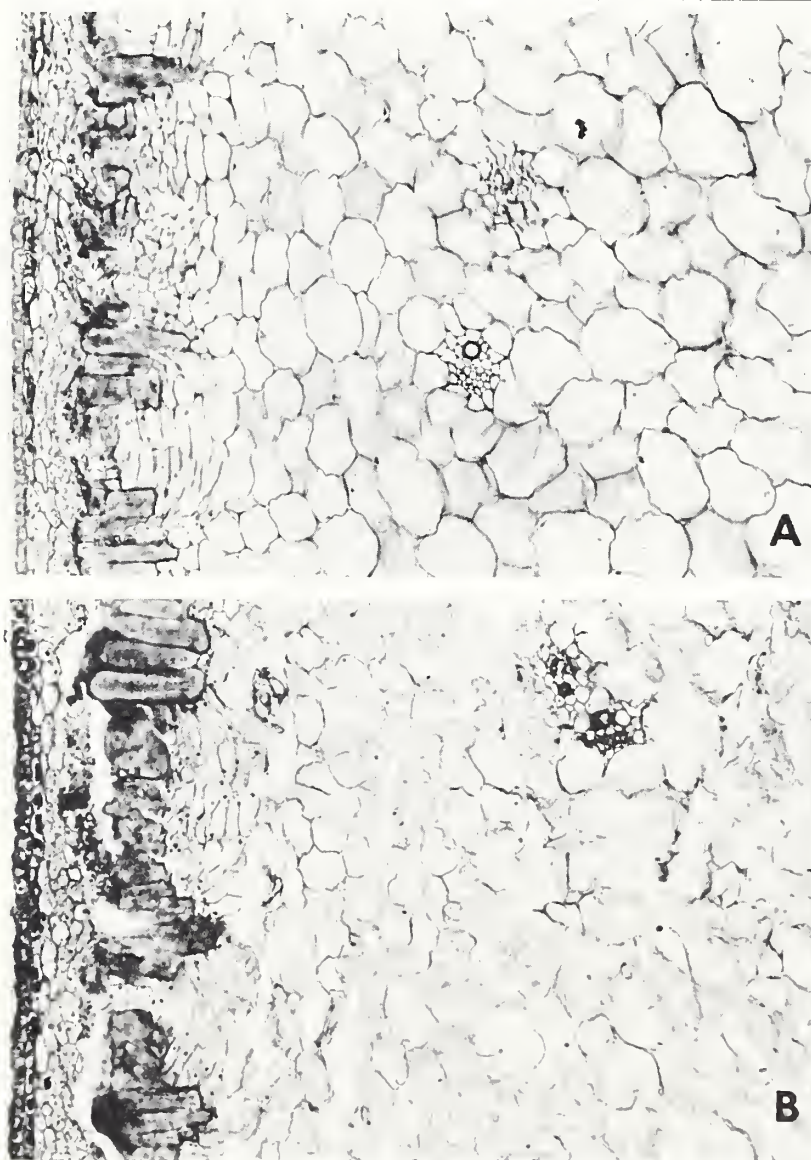


FIGURE 1. Transection from equatorial zone of Deglet Noor date fruit ($\times 417$). A = Kimri stage. B = Tree-ripe stage. Note intact cell walls in kimri stage and broken cell walls in tree-ripe stage. Cell walls of tough grades are similar to A while cell walls of tender grades are similar to B.

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studies of tough and tender grades of dates (2, 3, 5, 7).

Several authors (2, 3, 5, 7) have suggested that a relatively low concentration of reducing sugars in tough dates occurs as a result of the fruit drying on the palm before sufficient invertase activity has taken place to give the sugar composition that exists in tender grades of dates. The implication is that inversion occurs during maturation and ripening and that at least one phase of the ripening process (inversion) has been partially inhibited because of a moisture deficiency in fruit tissue. Continued translocation of sucrose into the maturing fruit where invertase activity becomes low could easily account for reducing sugar values of tough grades being similar to those of kimri or khalal stages of maturity, while total sugar content is similar to that of tender grades of tree-ripe dates.

Rygg (6) has suggested the possibility that inversion is less of a factor in quality than other hydrolytic reactions which may occur at the same time that inversion occurs. Although Maier and Metzler (2, 3) have demonstrated that additional invertase activity will soften firm dates, they recognized the possibility that other enzymes, probably present in the tissues, became operative under conditions favorable for invertase.

It seems unreasonable to assume that all of the textural differences are due to differences in moisture levels and relative concentrations of sucrose and reducing sugars. It does not necessarily follow that a routine fractionation, which by necessity is somewhat empirical, and chemical assay for cell wall material will show these differences. In fact, our data from number 1 dry and natural dates did not give us clear differences in pectin fractions, lignin, hemicellulose fractions and cellulose. When these same methods were used to evaluate relative amounts of polymers in various stages of maturity, substantial decreases in pectin, hemicellulose and cellulose were seen. Most of these changes, however, occurred between the kimri stage and the first stage of softening. Very little change was seen from the first stage of softening to the tree-ripe condition.

It appears, therefore, that available fractionation procedures of alcohol-insoluble solids tell us very little about factors that are responsible for textural differences between natural and number 1 dry dates.

HISTOLOGICAL STUDIES

Tissue from various grades and various stages of maturity of the 1966-67 crop were fixed in FAA, carried through standard histological procedures, stained with safranin-fast green, and examined with a light microscope.

Representative conditions are shown in photomicrographs (Figure 1) of tissue from kimri dates and tree-ripe dates. When tissue of tree-ripe fruit is compared with tissue from immature dates, it is obvious that a considerable loss of cell wall structure has occurred. These differences are in agreement with the findings of Long (1). He concluded that the change in texture during ripening is due, in part, to walls of the mesocarp cells becoming thinner and weaker and apparently being hydrolyzed until some of the cells had almost disintegrated.

Long did not study the various grades of dates, but our studies indicate that tougher dates (number 1 and number 2 dry grades) have a structure similar to that of kimri or khalal stages of maturity as far as intact cell walls are concerned while waxy and natural grades (tender dates) contain many broken cells. In many cases, cells of the tender dates are fractured and more highly disorganized than cells of the tree-ripe dates. It appears, therefore, that histological studies can be used to show a clear reason for textural differences based on differences in structural strength.

The less mature and the tougher dates may be firmer because the parenchyma cells possess rigid, intact walls. Vascular bundles and tannin cells occur in the mesocarp, and the mesocarp is bordered by a more or less continuous layer of stone cells (between the hypodermal layer and the mesocarp). This architecture could provide considerable structural strength. Intact parenchyma cells may hold the

stone cells, the vascular bundles and the tannin cells in fixed positions against relatively high forces, whereas parenchyma cells in various stages of structural disorganization would provide a relatively weak and fluid medium through which vascular strands, tannin cells and stone cells could flow. The net result may be a medium that is softer and apparently less "fibrous".

Although chemical studies show no clear differences between grades in structural materials such as pectins, hemicellulose and cellulose, histological studies suggest that pectinase, hemicellulase and cellulase should be tried in a search for tenderization methods. Physical measurements as well as histology should be used to evaluate the effectiveness of tenderization treatments.

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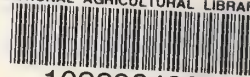
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